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ON BABINGTONITE

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In the course of a study of augite, acmite, aegirite, and other pyroxenes it became advisable to study the relationships of babingtonite to the monoclinic pyroxenes.

ARENDAL BABINGTONITE. Through the kindness of Dr. Shannon we obtained from the collection of the U. S. National Museum a specimen (No. 47035) of babingtonite from Arendal, Norway, the original locality. The mineral occurs as small (up to 1 mm. long) black glistening crystals, which occupy ramifying solution cavities in large microcline crystals. The cavities appear to have been once filled with albite.

The crystals of babingtonite are in habit stoutly prismatic nearly normal to the perfect cleavage; there is a less perfect cleavage in this prismatic zone. We have used Dauber's orientation which makes this zone vertical, the more perfect cleavage is the base $c(001)$ and the less perfect cleavage is the side pinacoid $b(010)$. This is the orientation used by Palache and Fraprie,¹ in their description of the Somerville babingtonite, and by Manjirô Watanabé for babingtonite from the Yakuki Mine, Japan.² They give tables of angles which we have used in determining the optical orientation. Dana's orientation relates the cleavages and certain parameters with those of the monoclinic pyroxenes, but the axial angles based on this orientation are not in good agreement. The planes $c(001)$, $b(010)$, $a(100)$, $h(110)$, and $g(2\bar{1}0)$ of Dauber's orientation correspond to $M(1\bar{1}0)$, $m(110)$, $c(001)$, $h(221)$, and $g(11\bar{1})$ of Dana's orientation.

The following optical orientation was determined for yellow light. One optic axis, A , emerges from the base at an angle in air of 37° , and the optic axial plane emerges from it at an angle in

¹ Palache and Fraprie, *Proc. Am. Acad. Arts and Sci.*, **38**, 383 (1902).

² *Am. Journ. Sci.*, **4**, 159 (1922).

air of 35° . The trace of the plane of the optic axes upon the base makes an angle of 35° with the trace of the less perfect cleavage. From the interference figure seen in a basal section $+2V$ appears to be about 70° and the acute bisectrix is roughly midway between $c(001)$ and $g(2\bar{1}0)$. The other optic axis, B , and likewise the plane of the optic axes, emerges from the face $g(2\bar{1}0)$ at an angle in air of 14° . The trace of the axial plane makes an angle of 21° with the trace of the less perfect cleavage and of 69° with that of the basal cleavage.

The angles, reduced when necessary to angles within the crystal, were plotted on a Nikitin hemisphere with the necessary crystallographic data. The optic axial angle thus found was $76^\circ \pm 3^\circ$. The φ and ρ values for the extremities of the ellipsoidal axes in the upper hemisphere are as follows:

	α	β	γ
ϕ	-36°	-147°	108°
ρ	44°	71°	53°

Thus, α emerges nearly midway between $c(001)$ and $k(\bar{1}10)$; β about 19° toward $c(001)$ from $h(\bar{1}\bar{1}0)$; and γ nearly midway between $c(001)$ and $g(2\bar{1}0)$. Measured from the cleavage traces the extinction on $c(001)$ is practically zero; on $b(010)$ it is 41° , with elongation positive in both cases.

Crossed dispersion of the optic axes and dispersion of the bisectrices are discernible in white light but are not very noticeable microscopically. At the axis B the dispersion is about twice as strong as A , but of the same character. At B within the crystal the axis for red is 2° beyond that for blue, with respect to the acute bisectrix; also, the axial plane for red is 4° nearer the normal to $g(2\bar{1}0)$ than the plane for blue. Thus, $2V_r - 3^\circ = 2V_b$, and the bisectrices are dispersed about 1° .

One of the most characteristic features of babingtonite is its strong pleochroism. The axes which represent the greatest contrasts in hue are nearly coincident with the axes of the index ellipsoid. In grains about .07 mm. thick α is deep green (about $37'''i$ or $37'''k$ Ridgway), β is a slightly purplish gray (about $67''''b$ or $67''''1$) and γ is an orange gray (about $16'''c$). These color comparisons were made by placing the Ridgway colors on the table beside the microscope, covering them closely with a white paper having an opening somewhat smaller than one of the color

rectangles, and then tilting the page away from the window until the white paper was illuminated approximately the same as the field of the microscope. In grains about 15 to 20 mm. thick α is nearly black, β is dull orange (about 9'''b), and γ is dull orange yellow (about 15'''h or 15'''h).

The refractive indices were measured microscopically by the immersion method. It was found that β is variable from 1.728 to 1.733. When this variation is taken into account the following refractive indices are probably representative: $\alpha=1.717$, $\beta=1.730$, $\gamma=1.752$; from which $+2V=75^\circ$.

The density of the Arendal babingtonite was determined by finding pycnometrically the density of Clerici's solution³ in which several crystals of the mineral were suspended. The density (grams per c. c.) at 26° is 3.359, with a variation of only $\pm .001$. This result is between the values obtained by Rammelsberg and by Silvia Hillebrand, which were 3.366 and 3.351 respectively.

SOMERVILLE BABINGTONITE. Some of the babingtonite studied by Palache and Fraprie was placed at our disposal by Prof. Palache through Dr. Fenner. This was found to vary in refractive indices between the same limits as the mineral from Arendal. It also showed the same optical aspects of cleavage fragments, of color, and of pleochroism. The density (at 25°) of the Somerville babingtonite was determined by the same method as that used with the Arendal material and was found to be 3.355, with a variation of $\pm .003$.

For the four occurrences which have been studied the refractive indices* of babingtonite are practically identical:

	α	β	γ	\pm
Arendal and Somerville	1.717	1.730	1.752	.002
Arendal ⁴	1.713	1.725	1.746	.003
Baveno ⁴	1.713	1.727	1.746	.003
Yakuki Mine ²	1.715	1.725	>1.74	.005

CHEMICAL COMPOSITION. An analysis was made of our specimen of the Arendal babingtonite, the material having been carefully purified from feldspar and epidote by means of heavy solutions and the magnet. About 4.45 grams were available; the powder was dried at 110° before analysis.

³ Enrico Clerici, *Rend. Accad. Lincei*, 16, 187, (1907).

⁴ E. S. Larsen, *U. S. Geol. Survey, Bull.* 679, 43, (1921).

TABLE I. ANALYSES OF BABINGTONITE

	1	2	3	4	5	1a	2a
SiO ₂	52.80	52.25	52.48	51.22	52.57	.880	.871
TiO ₂	0.29	0.18	trace	n. d.	n. d.	.004	.002
Al ₂ O ₃	2.41	5.27	1.93	n. d.	n. d.	.024	.052
Cr ₂ O ₃	none	n. d.	n. d.	n. d.	n. d.		
Fe ₂ O ₃	13.17	7.49	23.24	11.00	15.03	.083	.047
FeO	7.68	11.05	n. d.	10.26	6.61	.107	.154
MnO	1.89	1.94	0.37	7.91	6.62	.027	.027
MgO	0.92	0.46	1.55	0.77	n. d.	.023	.012
CaO	19.19	20.36	19.31	19.32	19.85	.343	.363
Na ₂ O	0.39	0.22	n. d.	n. d.	n. d.	.006	.004
K ₂ O	0.09		n. d.	n. d.	n. d.	.001
H ₂ O+	0.91	0.29	1.03	0.44	n. d.	.050	.015
	99.84	99.51	100.02	100.92	100.68		
Density	3.359	3.355		3.366	3.351		

1. Babingtonite, Arendal, Norway. Washington analyst.
2. Babingtonite, Somerville, Massachusetts. Fraprie analyst. Palache and Fraprie, *Proc. Am. Acad. Arts. Sci.*, **38**, 391, (1902).
3. Babingtonite, Buckland, Massachusetts. Schneider analyst. B. K. Emerson, *U. S. Geol. Survey, Bull.* **126**, 32, (1895), Includes H₂O—=0.11. FeO not determined for lack of material.
4. Babingtonite, Arendal. Rammelsberg analyst. *Pogg. Ann.*, **103**, 287, 304, (1858).
5. Babingtonite, Arendal. Silvia Hillebrand analyst. *Tsch. Min. Pet. Mitth.*, **32**, 256, (1914).
- 1a. Molecular ratios of No. 1.
- 2a. Molecular ratios of No. 2.

Our analysis of the Arendal mineral closely resembles those by Fraprie and by Schneider of the two New England occurrences in all essential respects, except the iron oxides. The relations of these in No. 2 are inverse to those in No. 1, and it would appear that in No. 2 more Al₂O₃ replaces Fe₂O₃. The total amounts of Al₂O₃, Fe₂O₃, and FeO are about the same in both. The small amount of material at hand did not permit Schneider to determine FeO, but making allowance for the presence of this the total amount of the same three oxides in his analysis is about the same as in the first two analyses.

The analysis by Rammelsberg is chiefly of historic interest; in the figures for SiO₂, CaO, MgO, and total iron oxides it resembles ours, but MnO is inordinately high and the ratio of the iron oxides is different. At the time when Rammelsberg made his analysis there was no good method for the determination of FeO in silicates, and the methods for manganese were also very uncertain in their

results as they are apt to be now. Silvia Hillebrand's analysis is so incomplete as to be of no value for discussion of the constitution of the mineral. It is similar to ours in SiO_2 , the iron oxides and CaO , but MnO is here also very high, Al_2O_3 is undetermined, probably included in her " MnO ," and the determination of magnesia, water, and the alkalis would raise the summation to a very unsatisfactory figure.

None of the few other analyses of babingtonite that have been published⁵ merit serious consideration. Those by Arpe and Thomson were the first made of the mineral and date from the 40's. Those by Forbes and by Heddle of minerals from Devonshire and from Ben Bhreck are poor and they are possibly not of babingtonite. That by Jehn of the Nassau babingtonite is a student's analysis and of little value. There is no analysis of the Baveno, of the Yakuki, or of the Passaic County, N. J.,⁶ babingtonite.

The chemical composition and the correct formula of babingtonite are not exactly known and there has been much diversity of opinion in the matter.⁷ A reason for this is obvious when the incompleteness and generally unsatisfactory character of the earlier analyses are considered. However, the better analyses agree as to certain main features. They show about 52 per cent of SiO_2 , about 20 per cent of iron oxides in varying proportions, about 20 per cent of CaO , and from about one-half to one per cent of $\text{H}_2\text{O}+$. Babingtonite is therefore essentially a silicate (presumably a metasilicate) of calcium and ferric and ferrous iron.

Babingtonite is commonly considered a triclinic member of the pyroxene group. Rammelsberg⁸ regarded it as a mixture of the molecules $(\text{Ca}, \text{Fe}, \text{Mn})\text{O} \cdot \text{SiO}_2$ and $\text{Fe}_2\text{O}_3 \cdot 3\text{SiO}_2$ in varying amounts. In this interpretation he has been followed by Dana,⁹ Groth,¹⁰ Naumann-Zirkel,¹¹ Lacroix,¹² Palache and Fraprie,¹³ and

⁵ See Hintze, *Handbuch der Mineralogie*, 2, 1171, (1897); and Doelter, *Handbuch der Mineralchemie*, 2, (2), 968, (1917).

⁶ C. N. Fenner, *Jour. Washington Acad. Sci.*, 4, 552, (1914).

⁷ For an account of some of the various views see Doelter, *Handbuch der Mineralchemie*, 2, (2), 969-972, (1917).

⁸ Rammelsberg, *Handbuch der Mineralchemie*, 2, 404, (1875).

⁹ Dana, *System of Mineralogy*, 383, (1892).

¹⁰ Groth, *Tabell. Uebers. Mineralien*, 4th. ed., 147, (1898).

¹¹ Naumann-Zirkel, *Elemente der Mineralogie*, 700, (1898).

¹² Lacroix, *Mineralogie de la France*, 1, 540, (1895); 4, 780, (1910).

¹³ Palache and Fraprie, *op. cit.*, 391.

by most other authors. Tschermak¹⁴ and Jannetaz¹⁵ give somewhat different formulae. Doelter¹⁶ considered that it is composed of the molecules $\text{CaO} \cdot (\text{Fe}, \text{Mn})\text{O} \cdot 2\text{SiO}_2$, $\text{CaO} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SiO}_2$, and $\text{CaO} \cdot \text{SiO}_2$. Silvia Hillebrand¹⁷ suggests a quite different constitution. According to her, babingtonite is a mixture of $2\text{CaO} \cdot 3\text{SiO}_2$ and $(\text{Ca}, \text{Fe})\text{O} \cdot \text{Fe}_2\text{O}_3 \cdot 2\text{SiO}_2$, that is dicalcium trisilicate and an iron anorthite. In support of this view she points out close crystallographic analogies between babingtonite and anorthite. Zambonini¹⁸ concludes from a study of four of the older analyses that Rammelsberg's interpretation is applicable with slight modification. He considers babingtonite a triclinic analogue of hypersthene, the two differing chemically in the presence of CaO and $(\text{Fe}, \text{Al})_2\text{O}_3$ in the former.

If the bases shown in the better analyses are calculated as metasilicates an excess of SiO_2 remains unsatisfied. This led to Miss Hillebrand's assumption of the presence of the hypothetical dicalcium trisilicate, while Doelter¹⁹ regarded this excess silica as present in solid solution. If, however, the $\text{H}_2\text{O} +$ that is found in the better analyses be regarded as hydroxyl, entering an acid silicate molecule, the mineral may be regarded as a metasilicate and Miss Hillebrand's and Doelter's suppositions may be disregarded.

The data for analyses Nos. 1, 2, and 4 are given below on the basis of metasilicate ratios.

	R_2O_3	RO	SiO_2 Calc.	SiO_2 found	Excess SiO_2	$\text{H}_2\text{O} +$
Arendal (H. S. W.)	.107	.507	.828	.884	.056	.050
Somerville (Fraprie)	.099	.560	.857	.873	.016	.015
Arendal (Rammelsberg)	.069	.549	.825	.854	.029	.024

A calculation which may more or less perfectly represent the two most complete analyses of babingtonite in terms of end members of a complex mixed crystal series is given in Table II. If these end members are named by analogy with pyroxenes the Arendal babingtonite contains about 49 per cent of "acmitic molecules," about 13 of "diopsidic molecules," and about 37 of "wollastonitic molecules."

¹⁴ Tschermak, *Lehrbuch der Mineralogie*, 515, (1905).

¹⁵ Jannetaz, *Les Roches et leurs Elements Mineralogiques*, 357, (1911).

¹⁶ Doelter, *Tsch. Min. Pet. Mith.*, 2, 198, (1880).

¹⁷ S. Hillebrand, *Tsch. Min. Pet. Mith.*, 32, 264, (1914).

¹⁸ Zambonini, *Atti Accad. Sci. Napoli*, 16, 24, (1914); *Zeits. Kryst.*, 55, 153, (1915).

¹⁹ Doelter, *Handbuch der Mineralchemie*, 2, (2), 972, (1917).

TABLE II. RECALCULATED COMPOSITION OF BABINGTONITE

	ARENDAL			SOMERVILLE		
	FOUND	100%		FOUND	100%	
FeO.Fe ₂ O ₃ .4SiO ₂	35.87	36.05	49.29	20.30	20.40	43.90
FeO.Al ₂ O ₃ .4SiO ₂	9.94	10.00		21.53	21.64	
Na ₂ O.Fe ₂ O ₃ .4SiO ₂	3.23	3.24		1.85	1.86	
CaO.MgO.2SiO ₂	4.97	4.99	13.43	2.59	2.60	24.00
CaO.FeO.2SiO ₂	1.73	1.74		14.63	14.70	
CaO.MnO.2SiO ₂	6.67	6.70		6.67	6.70	
CaO.SiO ₂	27.38	27.52	37.28	29.00	29.16	32.10
CaO.H ₂ O.2SiO ₂	9.71	9.76		2.93	2.94	
	99.50	100.00		99.50	100.00	
Excess SiO ₂	.36			0.01		
	99.86			99.51		

GENERAL RELATIONSHIPS OF BABINGTONITE. In the case of triclinic, chemically complex minerals like babingtonite so ill-defined are the limits of unlikeness permissible in what is called a group of minerals that classification is largely arbitrary. In our opinion babingtonite is too unlike anorthite chemically to be classed with it although they are sufficiently alike crystallographically, as was pointed out by Miss Hillebrand. On the other hand babingtonite is chemically much like the acmitic pyroxenes, although they are not known to form extensive mixed crystal series, and crystallographically they are too unlike to be classed together. Through the kindness of Dr. R. W. G. Wyckoff we are able to present evidence of the structural unlikeness of babingtonite and acmite, shown by the X-ray diffraction spectra from the powdered minerals (Fig. 1). The relative positions of the lines are measured horizontally from the central vertical line, and their relative intensities are represented by the lengths of the lines.

The triclinic acid sodium-manganese-calcium metasilicate schizolite has been compared with babingtonite by Bøggild,²⁰ who found the two to differ about as much as do babingtonite and the monoclinic pyroxenes. Pectolite and manganopectolite,²¹ which are rather closely related to schizolite, differ considerably from babingtonite. All of these minerals have two cleavages about as perfect as those of babingtonite and inclined at about the same angle. The range is from 84°40' in pectolite to 88°24' in babingtonite.

²⁰ O. B. Bøggild, *Meddels. om Groenland*, **26**, 121, (1904).

²¹ J. F. Williams, *Arkansas Geol. Survey, Ann. Rep.* (1890), **2**, 253, (1891); *Zeits. Kryst.*, **18**, 386, (1891).

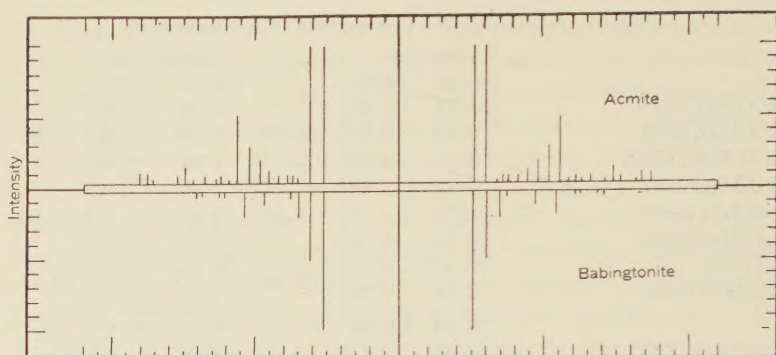


FIG. 1. X-ray Diffraction Spectra of Babingtonite and Acmite

By general agreement rhodonite and babingtonite have usually been grouped together. Another mineral, pyroxmangite, should be in this group, it seems to us, although its discoverers, Ford and Bradley,²² questioned such relationship. The angle between the two cleavages, which are similar to those of babingtonite, is $88^{\circ}10'$, almost identical with that in babingtonite. Optical differences, which Ford and Bradley considered important, we consider unimportant.

The chemical composition, determined by two closely agreeing analyses, was expressed by them as follows:

SiO ₂	0.786	
Al ₂ O ₃	.023	
FeO	.394	.717
MnO	.290	
CaO	.033	
H ₂ O	.018	

The ratio RO:SiO₂ is far from that of a metasilicate if the Al₂O₃ is assumed to be present in the Tschermak molecule, RO.Al₂O₃.SiO₂, as was done by Ford and Bradley. If, however, we assume the presence of FeO.Al₂O₃.4SiO₂, as was done with babingtonite, the exact metasilicate ratio is obtained, if the water is disregarded.²³ According to our interpretation the molecular composition of the pyroxmangite may be expressed as follows:

²² Ford and Bradley, *Am. Jour. Sci.*, **36**, 169, (1913).

²³ The pyroxmangite was intimately associated with an alteration product to which the composition 3MnO₂.2Fe₂O₃.6H₂O was assigned.

FeO.Al ₂ O ₃ .4SiO ₂	9.52
FeO.SiO ₂	48.97
MnO.SiO ₂	37.99
CaO.SiO ₂	3.83
H ₂ O	0.37
	<hr/> 100.68

Two other triclinic substances appear also to belong to the rhodonite-babingtonite group. One is the mineral sobralite,²⁴ a metasilicate of manganese, iron, lime, and magnesia, and the other is a slag product, called vogtite,²⁵ which is apparently like the triclinic babingtonite-like slag crystals described by Vogt.²⁶ These crystals have pyroxene-like cleavages and angles and were thought by their discoverers to belong with rhodonite and babingtonite.

SUMMARY

New determinations of the chemical and optical properties and the density of babingtonite have been made. Its unlikeness to the monoclinic pyroxenes has been discussed. The arbitrary character of the boundaries of mineral groups, especially triclinic groups, is mentioned, and it is suggested that babingtonite, rhodonite, pyroxmangite, and sobralite are sufficiently alike, and also unlike the pyroxenes and other mineral groups, to be grouped by themselves.

MAGNESITE CRYSTALS FROM ORANGEDALE, NOVA SCOTIA

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The unusual rarity of euhedral crystals of magnesite led the writer to make a special study of some obtained from Ward's Natural Science Establishment by Dr. A. F. Rogers a few years ago. The crystals come from a magnesite deposit near Orangedale, Inverness County, Nova Scotia, the occurrence of which was described by A. O. Hayes in 1916.¹

According to Hayes, the deposit was discovered by Alexander McLeod on the farm of John Martin, McLean Point road, about

²⁴ J. Palmgren, *Bull. Geol. Inst. Univ. Upsala*, **14**, 109, (1917).

²⁵ C. Hlawatsch, *Zeits. Kryst.*, **42**, 590, (1907).

²⁶ J. H. L. Vogt, *Studier over Slagger*, **1**, 37, (1884); *Mineralbildung in Schmelzmassen*, **71**, (1892); *Die Silikatschmelzlosungen*, **1**, 47, (1903).

¹ Sessional Papers of the Canada Department of Mines, Vol. LII, No. 17, p. 277, (1917).

a mile east of Orangedale, and " . . . an open cut about five feet wide by fifteen feet east and west through about three feet of surface sand and clay exposed the magnesite. It is in a weathered and friable condition over the whole extent of the stripping.

. . . Bedrock was not exposed in the cutting but small cores of dolomite occur in the magnesite and the six-sided prisms were found embedded in the cores. Fossiliferous dolomite interbedded with gypsum, probably forming part of the Windsor stage of the Carboniferous limestone series is well exposed about $\frac{1}{4}$ of a mile south of the magnesite prospect . . . Other outcrops of the Carboniferous limestone series occur to the north of the deposit, one within a few hundred feet, the other on the shore of the lake. The deposit of magnesite is apparently of secondary origin derived from the associated dolomites."

The magnesite crystals forming this friable mass range in size up to almost twelve millimeters in length, but of those used for measurements by the writer, none exceeded five millimeters. They vary in color from dark brown to almost colorless, and occur in two different crystal combinations which intergrade. Most common of these is the hexagonal prism with the pinacoid (fig. 1), while the other combination showed the presence of a new scalenohedral face *p*, together with a negative rhombohedron *f* (fig. 2). Associated with the magnesite are colorless rhombohedral crystals of dolomite. In the paper cited above, these were mentioned as another variety of magnesite and were described as "resembling a scalenohedron and nearly colorless." This is an error, however.

Qualitative analyses were made on both of the minerals. The magnesite yielded a heavy magnesium precipitate, with a small amount of calcium, and traces of iron and aluminum. The brown color of most of the crystals, which might be supposed to be due to the presence of iron, was found to be caused by organic matter. The analysis which Hayes gives for the weathered, crystalline magnesite is as follows:

CaCO ₃	2.85
MgCO ₃	90.80
Al ₂ O ₃	1.01
Oxide of iron (all expressed as Fe ₂ O ₃).....	1.71
Silica and insoluble residue.....	0.30
Equivalent to CaO.....	1.60
MgO.....	43.53

Qualitative tests made on the dolomite gave large precipitates of both calcium and magnesium, with a small amount of iron.

CRYSTAL FORM OF MAGNESITE

The predominating form is the second order prism $a \{11\bar{2}0\}$. The great majority of the crystals showed only this form, terminated by the pinacoid $c \{0001\}$. On the others observed, there were, in addition to the a and c faces, a negative rhombohedron $f \{02\bar{2}1\}$, and a negative scalenohedron p in the zone $[2\bar{1}10:02\bar{2}1]$. The symbol of this new scalenohedron was determined graphically by means of a gnomonic projection and found to be $\{4.8.\bar{1}2.5\}$.

The following angles on the two crystals were measured with a reflecting goniometer:

	AVERAGE OF:	MEASURED:	CALCULATED:
$a f (11\bar{2}0 \wedge 02\bar{2}1)$	(3).....	40° 5'	40° 10½'
$a^v p (2\bar{1}10 \wedge 4.8.\bar{1}2.5)$	(3).....	72 59½	73 0½
$p f (4.8.\bar{1}2.5 \wedge 02\bar{2}1)$	(3).....	17 4	16 59½
$p' f (\bar{8}.12.\bar{4}.5 \wedge 02\bar{2}1)$	(3).....	16 55	16 59½
$a^v f (2\bar{1}10 \wedge 02\bar{2}1)$	(3).....	90 3⅓	90 00
$p p' (4.8.\bar{1}2.5 \wedge \bar{8}.12.\bar{4}.5)$	(3).....	33 59	33 59

The angle $(10\bar{1}1 \wedge \bar{1}101)$ was measured on a cleavage fragment and found to be $72^\circ 40\frac{1}{3}'$ which agrees well with Koksharov's value ($72^\circ 36\frac{1}{3}'$).

GRAPHIC DETERMINATION OF THE p FACE

Since there are no tables of angles for magnesite, the new face was determined by graphical means, and then recalculated. In the graphic determination, the gnomonic projection was used as represented in fig. 3. As Rogers² has shown, the Penfield stereographic sheets may be used for the gnomonic projection as well. Scale no. 2 of these sheets gives the direct values of the angle tangents.

The $\{0001\}$ face appears as the point c in the center of the circle. The rhombohedral zone-lines are drawn as radii. The face $f \{02\bar{2}1\}$ is found by laying off the tangent of $61^\circ 55'$ (according to scale no. 2) along zone-line cM . The prism face $a \{11\bar{2}0\}$ is projected at infinity, and hence is represented by an arrow on

² School of Mines Quarterly, Vol. 29, pp 24-33, (1907).

the radial zone-line midway between the positive and negative rhombohedral zone-lines. Point L is located on the edge of the circle, where the zone-line ca^v and the circle intersect. Through f a line is drawn parallel to cL , (zone $[0001:2\bar{1}\bar{1}0]$), shown on the figure by the zone-line Da^v . Through L , and with f as the center, an arc is drawn, and the point where the arc cuts the projection of the line cf beyond c is called N , the *angle point* of the zone $[02\bar{2}1:2\bar{1}\bar{1}0]$. Using N as a center, an angle of $17^\circ 4'$ (the measured value of pf) was laid off from line fN as shown in the figure by angle pNf , in order to find the face p which lies on the zone line Da^v . The tangent of $43^\circ 8'$ ($0001 \wedge 10\bar{1}1$) was marked off from the center along the zone-line cE to locate $r \{10\bar{1}1\}$, and also along zone-line cM to locate $\{01\bar{1}1\}$. Perpendiculars were drawn through p, f , and $\{01\bar{1}1\}$ to the zone-line ca' , and through r and p to the zone-line ca^v . G is the point where the perpendicular from $r \{10\bar{1}1\}$ to the ca^v zone-line cuts the circle. Similarly point K is the intersection of the line from $\{01\bar{1}1\}$ perpendicular to the zone-line ca' with the circle, and point Q is the intersection of the zone-line cM with the circle. The three unit scale lines may now be drawn in. A line through Q perpendicular to the zone-line ca' locates one scale line; the line cG locates another, and cK is the third. Where cK extended cuts the perpendicular from p to the zone-line ca' determines the point Z , and the point where cG intersects the perpendicular from p to the zone-line ca^v is called R . The zone-line ca is drawn, and the point where this line cuts the scale line QH is J . The distance QJ is then the unit distance. Next, the line cp is drawn in and cp cuts the scale line QH at point F . The following distances were measured by means of scale no. 4 of the Penfield sheet:

$$\frac{QF}{QJ} = \frac{1}{2} \quad \text{or} \quad \frac{k}{h} = \frac{1}{2}$$

$$\frac{cZ}{cK} = \frac{8}{5} \quad \text{or} \quad \frac{h}{l} = \frac{8}{5}$$

$$\frac{cR}{cG} = \frac{4}{5} \quad \text{or} \quad \frac{k}{l} = \frac{4}{5}$$

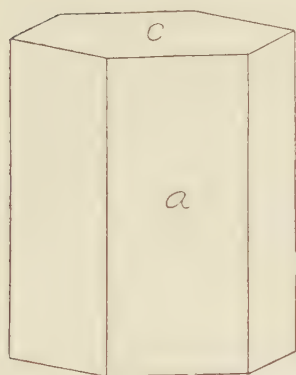


FIG. 1

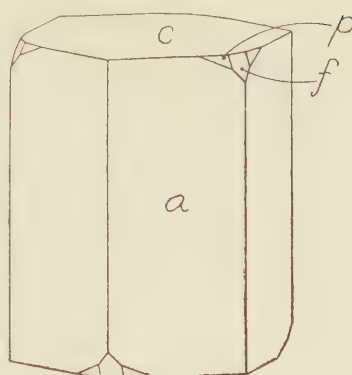


FIG. 2

Magnesite Crystals from Orangedale, Nova Scotia
 $c = \{0001\}$, $a = \{11\bar{2}0\}$, $f = \{02\bar{2}1\}$, $p = \{4.8.\bar{1}2.5\}$.

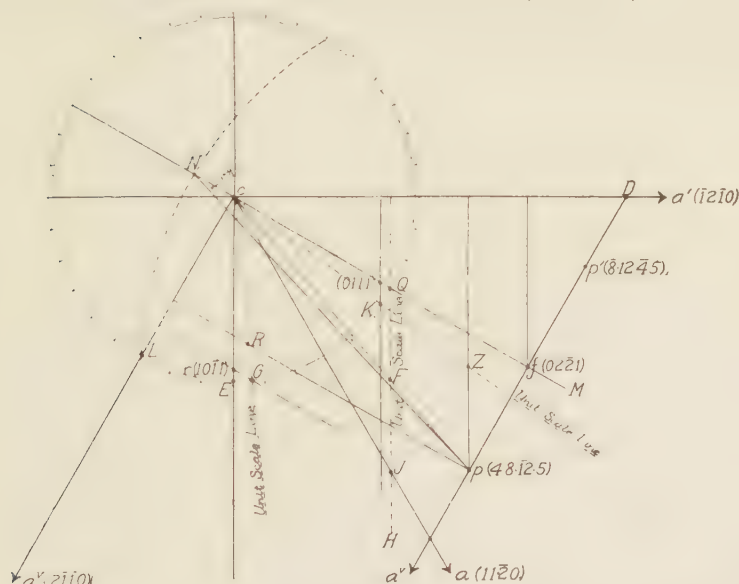


FIG. 3. Graphic Determination of a New Scalenohedron Face on Magnesite
 (made on a Penfield Stereographic Sheet)

The final step is to find the symbol of a face of the type $\{k.h.\bar{h}+k.1\}$ that will satisfy these conditions. This is one having 4 as the first term, 8 as the second, and 5 as the fourth, or $\{4.8.\bar{1}2.5\}$. This, then, represents the negative scalenohedron p , a form new for magnesite, but one known for calcite.

ANGLE MEASUREMENTS FOR DOLOMITE

The colorless associated mineral, already determined as dolomite by qualitative tests, was shown to be such by a study of the geometrical properties of its crystals. Various crystals were examined and it was found that the only forms present were the two positive rhombohedrons, $M \{40\bar{4}1\}$ and $r \{10\bar{1}1\}$, and the pinacoid $c \{0001\}$. The M face was the most prominent. Measurements were made with a reflecting goniometer, and the following averages were obtained:

	AVERAGE OF:	MEASURED:	RECORDED VALUE:
$c \ M \ (0001 \wedge 40\bar{4}1)$(3).....	75°	38½'	75° 25'
$c \ r \ (0001 \wedge 10\bar{1}1)$(3).....	44	12½	43 51½
$M \ M' \ (40\bar{4}1 \wedge \bar{4}401)$(3).....	113	53	113 53

Thanks are due Dr. Austin F. Rogers for invaluable assistance in the preparation of this paper.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, Sept. 13, 1923

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the President, Mr. Vaux, in the chair. Fourteen members were present. Mr. J. L. Darlington, having received the endorsement of the Executive Committee, was unanimously elected to membership in the Society. Reports of summer trips constituted the program of the evening.

Mr. Biernbaum reported on a trip which included some of the less known mineral localities of Connecticut and New York. Altogether thirty-six localities were visited and numerous specimens obtained. The trip included the following important localities: BEDFORD, N. Y.—A quarry one mi. from the old locality where abundant rose quartz of good quality was found. BRANCHVILLE, CONN.—Curved muscovite. ROXBURY, CONN.—A specimen of finely crystallized siderite found in gneiss was exhibited. ROXBURY FALLS, CONN.—Garnets. W. REDDING, CONN.—Brilliant red garnets (Essonite). The finds were of good quality but not of the gem variety. DANBURY, CONN.—An attempt was made to locate the type locality of danburite. The only indication was an abandoned silver mine, which may have been the source of the material. HADDAM, CONN.—On the dumps near the old Lepidolite mine, interesting mammillary forms of this mineral were found. A road cut beyond the mine yielded microcline and beryl, also fine doubly terminated tourmaline. ROCK LANDING QUARRY, No. 2—Located half mile north of old Rock

Landing Quarry—a new operation for feldspar. Fine beryl and large microcline were exhibited, while columbite was reported so abundant that the quarry owner was selling it for ore. **HALES QUARRY (PORTLAND TOWNSHIP)**—Torbernite and columbite were found in abundance, the dumps being reported as enormous. **WESTFIELD, MASS.**—In a trap quarry visited several fine specimens of datolite were obtained from the foreman.

Mr. Hoadley reported that a so-called platinum-iridium mine at Yonkers, New York, was recently visited and found to be a small drift into a hillside which yielded only magnetite. Mr. Boyle reported on trips to **SNAKE HILL** and **GREAT NOTCH, N. J.**, which yielded apophyllite, stilbite and natrolite at the former locality and prehnite, gmelinite, chabazite, natrolite, laumontite and amethyst at the latter. Mr. Vaux reported having visited the **BLACK HILLS** district and **RATTLESNAKE BUTTE, S. D.** Rattlesnake Butte rises 300 feet above the prairie in a knife edge three quarters of a mile long. The formation is entirely composed of sand-calcite crystals. Considerable material was brought back for exhibition. Mr. Vaux also stated that the collection at Toronto University was nicely displayed, the Cobalt region and Nova Scotia being especially well represented. A large specimen of mica, the commercial value of which approaches \$900, made a most interesting exhibit. Mr. Blank reported on a trip thru the slate quarrying region near **LEHIGH GAP**. The **CRYSTAL CAVE** at Kutztown was visited, where the temperature was 35° below the outside atmosphere. At **O'NEILLS QUARRY, FRANKFORD**, some molybdenite, pyrite and chalcopyrite were found.

Mr. Biernbaum stated he had been considering a suggestion for classes in Field Mineralogy which would give opportunity for studying this phase of the subject. It was agreed that all interested should meet at the home of Mr. Boyle on Wednesday, Sept. 26, to discuss and arrange details.

The meeting adjourned at 10 P. M.

J. C. BOYLE, *Secretary pro tem.*

YALE MINERALOGICAL SOCIETY

On October 5, 1923 an undergraduate Mineralogical club to be known as the "Yale Mineralogical Society" was organized at Yale University. The following officers were elected:—J. F. Schairer, President; E. D. Stirlen, Secretary; C. C. Lawson, Assistant-Secretary; E. J. Roberts, Treasurer.

The first meeting was held on October 16, 1923 at No. 181 Kirtland Hall. Professor W. E. Ford of the Yale Mineralogy Department addressed the society on the "*History of Yale's Mineralogical Achievements and a Program for the Future.*" The society will meet once a month.

The purpose of the organization is to promote interest in Mineralogy and Crystallography; and to secure interesting speakers to address the monthly meetings. From time to time brief papers on assigned problems will be given by undergraduate members.

J. F. SCHAIRER, *President.*

NEW MINERALS: NEW SPECIES

CLASS: SULFATES. DIVISION: $R' : R'' : (SO_4) : H_2O = 1:3:2:3$ **Argentojarosite**

WALDEMAR T. SCHALLER: Argentojarosite, a new silver mineral. Preliminary note. *J. Wash. Acad. Sci.*, **13**, (11), 233, (1923).

NAME: From the composition, a *jarosite* containing silver (*argentum*).

CHEMICAL PROPERTIES: *Formula*, $Ag_2O \cdot 3Fe_2O_3 \cdot 4SO_3 \cdot 6H_2O$ or $AgFe_3(SO_4)_2 \cdot (H_2O)_3$. Mean of several analyses approximates to: Ag_2O 18, Fe_2O_3 43, SO_3 28, H_2O 10%; some K_2O and PbO also present.

CRYSTALLOGRAPHIC PROPERTIES: Hexagonal; in small scales.

PHYSICAL AND OPTICAL PROPERTIES: Color, yellow to brown; uniaxial, negative; closely resembles jarosite.

OCCURRENCE: From the Titanic Standard mine, Dividend, Utah. Apparently sufficiently abundant to be mined as an ore.

DISCUSSION: The first silver mineral recorded containing oxygen.

E. T. W.

CLASS: PHOSPHATES, ETC. DIVISION: ARSENITES

Finnemanite

G. AMINOFF: Finnemanit, ett nytt blyarsenit från Långban. (Finnemanite, a new lead arsenite from Långban). *Geol. För. Förh.*, **45**, (1-2), 160-163, (1923).

NAME: After K. J. Finneman of Långban, who first observed it.

CHEMICAL PROPERTIES: *Formula*, $Pb_3Cl(AsO_3)_3$.

Theory: PbO 77.5, As_2O_3 20.6, Cl 2.5, less $O = Cl$ 0.6, sum 100.0%. Analysis by Dr. G. Karl Almström gave: PbO 76.83, As_2O_3 20.54, Sb_2O_3 trace, CaO 0.39, FeO trace, Na_2O 0.24, K_2O 0.44, Cl 2.42, less O for Cl 0.55, sum 100.31%. All the arsenic is arsenious; fluorine is absent.

CRYSTALLOGRAPHIC PROPERTIES: Hexagonal; $c = 0.6880$, or in alternate position 1.1917. Forms *c*, *m*, and *p*; also vicinal prism and pyramids. $\rho_p = 38^\circ 28'$, and $\rho_o = 0.7945$. Habit, prismatic, terminated by large pyramid and small base, showing considerable form-distortion, but apparently holohedral. Cleavage distinct, pyramidal.

OPTICAL PROPERTIES: Sign—; $\omega = 2.295$, $\epsilon = 2.285$ (for D).

PHYSICAL PROPERTIES: Color gray to black, in thin flakes somewhat olive green. Luster high, almost adamantine. Hardness 2.3; sp. gr., Almström obtained 7.08; Flink 7.265.

OCCURRENCE: As a crystalline crust on the walls of crevices in granular hematite ore, in the Hindenburg shaft at Långban.

DISCUSSION: A well described species.

E. T. W.

CLASS: COLUMBATES. DIVISION: $R'' : R' : Cb = 5 : 1 : 6$ (?)**Ishikawaite**

YUJI SHIBATA and KENJIRO KIMURA: Ishikawaite, a new mineral from Ishikawa, Iwaki province. *J. Chem. Soc. Japan*, **43**, 648-649, (1922); thru *Chem. Abstr.* **17**, 252, 1923.

This is the "unnamed" mineral already abstracted in *Am. Min.*, 7, (11), 197, 1922; the chemical and physical properties are there recorded.

NAME: From the locality, *Ishikawa*.

CRYSTALLOGRAPHIC PROPERTIES: System orthorhombic; $a:b:c=0.9451:1:1.1470$. Forms: c (001), a (100), g (210), h (320), m (110), n (140), b (010), r (144) and d (101). The angles of these forms are quite distinct from those of any of the known columbates approaching this in composition.

DISCUSSION: May be accepted as a new columbate.

E. T. W.

BOOK REVIEW

THE ANALYTICAL EXPRESSION OF THE RESULTS OF THE THEORY OF SPACE-GROUPS. RALPH W. G. WYCKOFF. 180 pages, 1922. Carnegie Institution of Washington, D. C. Publication No. 318.

This book is a contribution to crystallography, altho that would hardly be the impression from a casual glance at any but the first or last 10 pages. It begins with a 3-page historical introduction, in which the development of modern ideas of crystal structure is very briefly outlined. (Fedorov's name is consistently misspelled Federov.) In Chapter 2 the nature of space-groups is discussed. The conceptions of axis, plane, and center of symmetry, "screw-axis" and "glide-plane" of symmetry are first defined. Under the heading of "point-groups" the 32 classes of symmetry are then treated, symbols for them being derived. Table 1 is one to which crystallographers will often refer to find out what these symbols mean as it gives a list of the names applied to the 32 classes by Schoenflies, Dana and Groth, with the corresponding symbol in the new plan. The names and numbers used by Miers, Tutton, and other English crystallographers might well have been added for completeness, but the numbers at least can be written in. The analytical expression of the point-groups is then taken up, and the derivation from them of space-lattices and space-groups is outlined.

Chapter 3, but 8 pages in length, covers the whole subject of the application of the theory of space-groups to crystals. It seems hardly adequate to give anyone unacquainted with the subject much of an idea as to how to use the method or even what it is all about. Chapter 4, the complete analytical expression of the space-groups, forms the bulk of the book. This is, of course, of great reference value. The book closes with 10 pages of tables assigning the various space-groups to the 32 classes of the 6 (7) crystal systems.

From the mathematical point of view the preparation of such a book is of the greatest value, and the author is certainly to be congratulated on his courage and industry in undertaking such a laborious piece of work. Crystallographers are likely to be a bit disappointed that detailed and practical directions are not given so that they can readily apply the method to their problems. For they are less interested in whether the space-group of a given substance is C_{4v}^{12} or C_{4v}^{11} than in the question whether the internal structure of the crystal agrees in symmetry class with its external form or not.

W.

NOTES AND NEWS

Through the courtesy of the Danish Government the Academy of Natural Sciences of Philadelphia was enabled to send an expedition to southern Greenland, of which Mr. Samuel G. Gordon was the sole personnel. Leaving England on July 1, Ivigtut was reached eleven days later. Camps were established at Nar-sarsuk and the various localities on the Kangerdluarsuk and Tunugdliarfik fiords. He returned to Philadelphia on November 11th. This represents the second Vaux-Academy expedition.

Attention is called to the Fourth Annual Meeting of the Mineralogical Society of America which will be held at Washington, D. C. on December 29, 1923, at 9:30 A. M. in conjunction with the Geological Society of America. It is requested that titles of papers be sent to the Secretary immediately.

A special volume of the *Zeitschrift für Kristallographie* has been published in honor of the eightieth birthday of the founder and first editor, Professor P. von Groth.

CORRECTIONS TO VOLUME 8

- No. 4, p. 63, 16th line, for "Anderson" read "Andersen."
 p. 70, 20th line, for "mariolitic" read "miarolitic."
 p. 74, 16th line, for "Henry S. Wallace" read "Henry C. Wallace."
 p. 74, 5th line from bottom, for "Earths" read "Metals."
 p. 75, 12th line, for "1907" read "1917."
 p. 76, 7th line from bottom, for "crystals giving results are as useful as 5 or 10" omit "are."
 p. 79, 16th line, for "fluoroite" read "fluorite."
 No. 7, p. 122, 15th and 16th lines, for "indicated by dots surrounded by circles, theoretical values by small squares," read "indicated by solid circles, theoretical values by small open circles."
 p. 124, end of 15th line, insert "))."
 p. 127, 15th line for "birefrigence" read "birefringence."
 p. 130, 5th line for "C. L. Ross," read "C. S. Ross."
 p. 130, 6th line, for "Wyckhoff" read "Wyckoff."
 No. 10, p. 181, 6th line from bottom, for " 3SiO_2 " read " 5SiO_2 ."
 p. 186, page references for Magnalite and Fluosiderite, read "188" instead of "189."

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PREPARED BY EDW. F. HOLDEN

Original articles are in **bold face type**; abstracts and cross references are in ordinary type. To save space only minerals described in more or less detail are indexed; titles of abstracted articles are not cross-indexed under authors' names; titles of articles by two or more authors are given only under the name of the senior author.

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